**Summary: Teaching the Concept of Cellular Transport**

**Grade 12 University Biology**

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Prior Knowledge

Students should have the following knowledge before the section on cellular transport is commenced in class:

* Understanding of the semi-permeable fluid mosaic model of the cell membrane
* Functions, nutrients needed, and wastes created by cell organelles
* Knowledge and understanding of terms such as polar, non-polar, hydrophilic, hydrophobic, concentration, etc.

Background Information: Cellular Transport

* The cell membrane is semi-permeable, which means that it will only allow specific substances to enter and leave the cell.
* Small molecules such as oxygen, carbon dioxide, and water can pass through the membrane using passive transport. PASSIVE TRANSPORT means that the cell does not need to expend energy to allow for substances to be transported across its membrane. Two kinds of passive transport are diffusion and osmosis.
  + DIFFUSION: the tendency for molecules of any substance to spread out evenly into available space. A substance will diffuse from where it is more concentrated to where it is less concentrated (which can also be said to “diffuse down its concentration gradient”).
  + OSMOSIS: The diffusion of water across a selectively permeable membrane is called osmosis. Water diffuses across the membrane from a region of lower solute concentration to an area of higher solute concentration, until the solute concentration on both sides of the membrane is equal.
    - Due to osmosis, solutions can cause cells to gain or lose water, depending on the concentration of solutes found in the solution, which are not able to cross the cell membrane.
    - If the cell is found in a solution containing more nonpenetrating solutes (hypertonic solution) than the cell, then the cell will lose water to its environment, shrivel and die.
    - If the cell is found in a solution containing less nonpenetrating (hypotonic solution) solutes than the cell, then water will enter the cell and it will swell and burst.
  + FACILITATED DIFFUSION: some polar molecules that diffuse passively (not requiring energy) use transport proteins that span the membrane to cross it. Channel proteins are very specific and only transport particular substances and not others.
* But larger hydrophilic molecules cannot cross the cell membrane unless there is a special mechanism in place to allow for the transport. ACTIVE TRANSPORT is the mechanism by which the cell transports substances against their concentration gradient; the cell must expend energy to do this. One kind of active transport uses carrier proteins, or protein pumps that span the cell membrane to transport the particles against their concentration gradient.
* Another kind of active transport exists for larger particles that require a vesicle to move them through the cell membrane. There are two mechanisms for this:
  + EXOCYTOSIS: The cell gets rid of macromolecules through fusion of vesicles with the plasma membrane. Vesicles containing macromolecules bud out of the golgi apparatus and move to the plasma membrane. When the vesicle comes in contact with the cell membrane, the lipid bilayer of both the vesicle and the plasma membrane rearrange to fuse together, spilling the contends of the vesicle outside of the cell.
  + ENDOCYTOSIS: Cellular uptake of macromolecules and other large particles by localized regions of the plasma membrane that surrounds the substance and pinch off to form an intracellular vesicle. This is done when a small area of the plasma membrane sinks inward to form a pocket, which deepens and pinches in forming a vesicle that contains material that had been outside of the cell.

Teaching Ideas

* Use demonstrations like Osmosis in Celery to hook students in introduction of the topic and have them inquire about the reasoning of their observations.
* Have a kinaesthetic representations (by having students role-play) to demonstrate exocytosis and endocytosis.
* Use many virtual labs/ online videos to ensure the understanding of the concept
* Many assessment forms throughout the concept teaching to diagnose student understanding.
* Laboratory exploration of the effects of solutions of different tonicity on cells.

Curriculum Expectations Addressed (Grade 12: Biochemistry)

B2.1 use appropriate terminology related to biochemistry, including, but not limited to: active and passive transport, covalent and ionic bond, allosteric site, substrate, substrate-enzyme complex, and inhibition [C]

B2.2 plan and conduct an investigation to demonstrate the movement of substances across a membrane (e.g., the effects of salt water and distilled water on a potato) [IP, PR]

B3.6 describe the structure of cell membranes according to the fluid mosaic model, and explain the dynamics of passive transport, facilitated diffusion, and the movement of large particles across the cell membrane by the processes of endocytosis and exocytosis

Lesson Sequence and Assessment/Evaluation

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| **Lesson Sequence** | **Expectation Codes** | **Lesson Strategy** | **Assessment/Evaluation** |
| Cellular Transportation Introduction | B2.1  B2.2  B3.6 | * Hook: Teacher firstly displays a celery that has just been placed in water with food colouring and asks students what they think would happen if we left the celery in the dyed water for a day? (Teacher can initiate discussion and probe student thinking). Teacher then shows students a celery stick that has already been placed in the dyed water for a day. Ask students if they want to change their theory as to what happened? * Lesson: After this initial hook discussion the teacher will give a lesson using board manipulates of the cell plasma membrane. Discuss that cells need nutrients to enter them and wasted to exit. This is done through several ways. Briefly explain passive transport, active transport, endocytosis and exocytosis. And explain to students that for the next couple of days we will be going into more details of these processes. | * Students participation in discussion will be used as a diagnosis of prior knowledge (K/U, C/I) |
| Passive Transport Investigation | B2.1  B3.6 | * This lesson will go into the details of diffusion, osmosis and facilitated diffusion. Students will also learn the effects of solution tonicity on cells. Teacher will give students a worksheet to be completed as they explore the following virtual lab:   (<http://programs.northlandcollege.edu/biology/Biology1111/animations/transport1.html>)   * After exploring the lab students will write a summary of their understanding of passive transport and how they can relate it to the osmosis in celery demonstration from previous day. This is to be submitted along with their worksheet. | * Worksheet submission (K/U) * Summary and “osmosis in celery” discussion in written work (K/U, T/I, C) |
| Lab Exploration: Osmosis and Tonicity | B2.1  B2.2  B3.6 | * Students will place potato cubes in beaker with tab water and another beaker with salt water. They will need to measure and record the mass of each potato piece and its texture before the exploration. Then after one day, weigh the pieces and record their masses and any changes in texture. * In class, after the experiment on the second day, teacher will facilitate a discussion on findings and hypothesis of what may have happened. * Students create a song that will help them remember what happens to cells in isotonic, hypotonic or hypertonic solutions. | * Students will submit a lab report including the following: introduction, methods, results and discussion   (K/U, T/I, C,A) |
| Active Transport, Exocytosis and Endocytosis | B2.1  B3.6 | * This lesson will go into the details of active transport. Teacher will give students a worksheet to be completed as they explore the following virtual lab:   (<http://programs.northlandcollege.edu/biology/Biology1111/animations/transport1.html>)   * After exploring the lab, teacher will facilitate a role play activity on endocytosis and exocytosis. Most students will make up the cell membrane, some will be the membrane of the vesicle, and some will be macromolecules outside the cell or within the vesicle. | * Worksheet submission (K/U) * Role play discussion (K/U, T/I, C) |
| Application of Cellular Transport |  | * Students will be placed in to groups and they will research the answers to one of these questions. Their group will then present their findings to the classroom:  1. Red blood cells (with the help of haemoglobin) pick up oxygen in the lungs and drop it off to the rest of the body tissues. Explain how this is an example of diffusion in action. 2. How do you think heavy use of fertilizer may affect plant cells? 3. What happens when you water a wilting plant? 4. What happens when you spray air freshener in a room? | * Research into topic and compilation of notes (K/U, A, T/I) * Group Presentation (C) |

Advance Preparation

* Complete Osmosis in celery experiment one day prior to the experiment, in order to display to students what happens
* Book computer labs for the virtual explorations
* Purchase materials for lab explorations

Special Materials

* Cell membrane magnetic manipulative (to use on board)
* Material for labs: celery, potatoes, salt
* Computer lab for virtual explorations
* Worksheets and rubrics for explorations and activities

Safety Considerations

* Ensure students do not have allergies to any of the materials used in labs (celery, potatoes, etc.)
* As students will be using computers to complete virtual labs and research it is important that teacher ensures students are aware of appropriate and acceptable computer use
* Stress that no inappropriate behaviour, or goofing around is to take place during role-play activity and laboratory experiment

Potential Student Misconceptions and Difficulties

* Misconceptions:
  + Students may think that particle movement depends on the concentration differences of all substances. But, during diffusion, each substance moves down its own concentration gradient, unaffected by the concentration differences of other substances. This is important to note to students during the lab class discussion.
  + Molecular motion stops when equilibrium is reached. This is not true; in fact molecules are always in motion.
  + Diffusion happens at the same speed and is not affected by concentration difference. Actually, diffusion is affected by concentration, temperature, size of molecules and charge.
* Difficulties
  + Students may have a difficult time understanding how the fusing of vesicle and cell membrane takes place in endocytosis and exocytosis. A recommended solution to this is the role play activity, described above.
  + Some students may be confused about the difference between diffusion and osmosis. I found that the virtual lab chosen, addresses this confusion very well.

Differentiated Teaching and Assessment

* Throughout this concept teaching there will be several different teaching strategies and assessment pieces that are created based to address different types of intelligences within the classroom:
* Musical: students create a song that will help them remember what happens to cells in isotonic, hypotonic or hypertonic solutions.
* Logical-Mathematical: Laboratory report of Osmosis in Potatoes and Tonicity
* Linguistic-Verbal: Discussion and answering of application problems in written submissions and group work
* Visual-spatial: 2 different virtual labs will be used during the teaching of this concept
* Intrapersonal: Students will submit a written piece explaining their understanding of passive transport after exploring the virtual lab
* Interpersonal: Presentation of an application of cellular transportation
* Bodily-Kinaesthetic: Student role play of endocytosis and exocytosis
* For ELL and IEP students the following considerations can be made:
  + These students may have difficulties with the new terms that are introduced in the lab. Many visual aids are used in the lesson sequence suggested above (videos, demonstrations, class role-play) and these will hopefully assist the students in understanding the concepts. In addition to this, these students could be paired with peers that have a good understanding of the concept and should be offered extra help from the teacher as well. Teacher should diagnose understanding of these students at the end of each lesson.

Applications and Societal Issues/Implications

* The following applications will be explored by students in groups and presented to the rest of the class:
  + Turgidity in plants due to osmosis
  + Diffusion is how the scent of air fresheners fills a room
  + Affects of fertilizer on plant cells
  + Oxygen and carbon dioxide transport between blood cells and muscle cells

Annotated References/Annotated Internet Addresses

1. Interactive lab on [Membrane Transport](http://www.wiley.com/college/pratt/0471393878/student/animations/membrane_transport/index.html) from Purdue University:

<http://www.wiley.com/college/pratt/0471393878/student/animations/membrane_transport/index.html>

1. Interactive lab on [Passive Transport: Diffusion](http://www.wisc-online.com/objects/index.asp?objID=AP1903) by Wisconsin Online

<http://www.wisc-online.com/objects/ViewObject.aspx?ID=AP1903>

1. Interactive lab on [Passive Transport: Osmosis](http://www.wisc-online.com/objects/index.asp?objID=AP11003) by Wisconsin Online

<http://www.wisc-online.com/objects/ViewObject.aspx?ID=AP11003>

1. Interactive lab on [Passive Transport: Filtration and Facilitated Diffusion](http://www.wisc-online.com/objects/index.asp?objID=AP11103) by Wisconsin Online

<http://www.wisc-online.com/objects/ViewObject.aspx?ID=AP11103>

1. Interactive lab on [Transport Processes Requiring ATP](http://www.wisc-online.com/objects/index.asp?objID=AP11203) by Wisconsin Online

<http://www.wisc-online.com/objects/ViewObject.aspx?ID=AP11203>

1. [Interactive Cellular Transport](http://www.wiley.com/legacy/college/boyer/0470003790/animations/membrane_transport/membrane_transport.htm) by Rodney F. Boyer

<http://www.wiley.com/legacy/college/boyer/0470003790/animations/membrane_transport/membrane_transport.htm>

1. Step by step animation of [Passive and Active Transport](http://programs.northlandcollege.edu/biology/Biology1111/animations/transport1.html) from Northland Community and Technical College

<http://programs.northlandcollege.edu/biology/Biology1111/animations/transport1.html>

1. [Membrane](http://highered.mcgraw-hill.com/sites/0072437316/student_view0/chapter6/animations.html) transport animations by McGraw-Hill
2. Osmosis Labs

* Osmosis in an egg <http://www.biologycorner.com/worksheets/observing_osmosis.html>
* Osmosis in Potatoes <http://www.nclark.net/OsmosisPotatoes.htm>

1. Diffusion Labs

* <http://www.biologycorner.com/worksheets/diffusionlab.html>
* <http://pslc.ws/macrog/kidsmac/activity/bear.htm>